GRANGE PUBLIC SUPPLY

GROUNDWATER SOURCE PROTECTION ZONES

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1. SUMMARY OF WELL DETAILS

GSI no.	:	2007NEW001
Grid ref.	:	21739 08164
Owner	:	Waterford Co. Co.
Well type	:	Bored
Elevation (top of casing)	:	83.60 m OD (Poolbeg).
Depth	:	25 m
Depth of casing	:	unknown
Diameter	:	203 mm (8")
Depth-to-rock	:	Unknown (probably 3-10m)
Static water level	:	74.6 m O.D. (9.0 m b.g.l.) on 10/7/92
Pumping water level	:	67.0 m O.D.(from pumping test)
Drawdown	:	7.6 m on 10/7/92 (from pumping test)
Abstraction rate	:	130 m^3/d (20 gal/min) on 28/2/96
Normal consumption	:	Variable; from 55 m^3/d (12,000 gal/d over approx 10 hrs) up to 115 m^3/d (25,000 gal/d)

Pumping test summary:

(i) abstraction rate : 250 m^3/d
(ii) specific capacity : 33 m^3/d/m (1 hour)
(iii) transmissivity : 25 m^2/d [10–40 m^2/d]

2. METHODOLOGY

There were three stages involved in assessing the area, a detailed desk study, site visits and fieldwork, and analysis of the data. The desk study was conducted in the Geological Survey where the subsoil and bedrock geologies were compiled from 1:25,000 scale maps. Basic public supply well details were recorded by County Council personnel in the form of a questionnaire which included precise locations and any relevant borehole, chemistry and pumping test data available.

The second stage comprised site visits and fieldwork in the surrounding area. A three hour recovery test was followed by a one hour pumping test in July 1992 in order to examine the aquifer characteristics. Subsequently, field work was carried out in the area encompassing a circle of 1 km radius in order to examine subsoil and bedrock geology, hydrogeology, vulnerability to pollution and current pollution loading. Finally, two raw water samples were taken, in September 1992 and June 1993 for full suites of chemical and bacterial analyses.

Stage three, the assessment stage, utilised analytical equations, hydrogeological mapping and groundwater modelling to delineate protection zones.

3. WELL LOCATION AND SITE DESCRIPTION

The source is the main public supply well for the area around Grange and it is located 300 m south west of Grange, along the main Dungarvan to Youghal road (Figure 1). The well is in a small pumphouse in the grounds of the old Grange creamery, which is now used to store inorganic fertilizers.

4. TOPOGRAPHY, SURFACE HYDROLOGY AND LAND USE

The well lies in a small north-south trending stream valley, at a height of 83.6 m O.D. Land rises gently to the west, east and north east of the well, up to a height of 110 m O.D.

The well is located 20 metres to the west of a stream which flows southwards towards Whiting Bay.

The land use in the area is primarily grazing.

5. GEOLOGY

5.1 Bedrock geology

The public supply is located in the Ballytrasna Formation (Old Red Sandstone). The formation consists predominantly of compact purple siltstones and mudstones, with minor sandstone units. Outcrops occur 500 m to the south of the well where the bedrock dips steeply to the north (70°), however in general the bedrock is poorly exposed. Approximately 700 m to the north of the well the Ballytrasna Formation is overlain by the Gyleen Formation. This formation consists predominantly of red/grey sandstones with minor siltstone and mudstone units. These beds dip approximately 65° to the north.

5.2 Quaternary (subsoils) geology

The subsoils in the area surrounding the well are also poorly exposed, in general the stream valleys appear to have rock close to the surface with thin sandstone till covering most of the remaining area (Figure 2). The till is generally described as red - brown in colour with a sandy matrix and poorly sorted subangular to subrounded mudstone clasts (the Ballyvoyle Member). A silt and clay rich till (the Whiting Bay Member) was deposited over low lying coastal embayments along the south west coast of Waterford prior to the deposition of the Ballyvoyle Member, however this till is not thought to extent as far inland as Grange.

5.3 Depth-to-rock

Outcrops can be seen 500 m to the south of the well and along the streams further to the east. Evidence from borehole records and Quaternary mapping in the general area suggests that the depth to bedrock in the remaining areas is generally between 3 and 10 m. Outcrops and proposed depth to bedrock contours are shown on Figure 2. The depth-to-rock has been contoured for ease of incorporation into the vulnerability map but it is based on few data points and may need refining as further borehole records become available.

6. HYDROGEOLOGY

6.1 Data availability

Hydrogeological data for the area around Grange are poor. A brief well survey was conducted during the site visit on the 28/2/96. Water levels from two wells in the area around the public supply were measured. Although records of four other wells exist for the wider area around the well, the location of three of these were not determined accurately (only a townland name is available). A 3 hour recovery test was followed by a 1 hour pumping test in July 1992, the duration of test was restricted because of problems with the pump cutting in and out. A longer test would have been more preferable.

6.2 Groundwater levels

Groundwater levels in the area are variable, depending on the time of year. The static water level in the public supply was 74.6 m O.D. (9.0 m b.g.l.) on 10/7/92. The pump in the well is operational depending on the pressure in the distribution system. At the time of the visit on 28/2/96 the pump was cutting in and out every 5 - 10 minutes. The water level after 10 minutes of recovery was 9.4 m b.g.l.

Groundwater level Data for the area around Grange public supply

Townland	Grid Reference/Townland (dependant on data accuracy)	Water Level (m O.D. Poolbeg)	Static Water Level (below ground level)
Drungullane East	21570 08185	97m O.D.	6.7 m
Knockmeelmore	Townland Accuracy	-	6.1 m
Grange	Townland Accuracy	-	12.2 m
Grange	Townland Accuracy	-	3.7 m
Grange	21709 08145	93m O.D. (Approx)	7.6 m
Ballylangadon	21722 08271	103m O.D. (Approx)	12.8 m

6.3 Groundwater flow directions and gradients

Groundwater flow to the well is likely to be dominated by flow from the hill immediately to the west which acts as a recharge mound, this is supported by the available groundwater level data. Due to the lack of groundwater level data it is not possible to obtain an accurate groundwater gradient. However, an approximate gradient (between 0.03 and 0.08) is proposed, based on modelling and experience of this formation elsewhere.

6.4 Meteorology and recharge

Rainfall data for the area are taken from a contoured rainfall map of Waterford (Duffy, 1993) based on data from the Meteorological Service. For the years 1951 - 1980 the mean annual rainfall for the area was 1050 mm. Evaporation data for the area are taken from a national contoured map as recorded by the Meteorological Service. Potential evapotranspiration (P.E.) is estimated as 560 mm/yr. Actual evapotranspiration (A.E.) is then calculated by taking 95% of the potential figure, to allow for soil moisture deficits for part of the year, so A.E. is estimated as 532 mm/yr. Using these figures the effective rainfall (E.R.) is taken to be approximately 518 mm/yr.

Although the subsoils are relatively thin and moderately permeable several perennial streams are present in the area and the bedrock has a relatively low permeability. This suggests that a proportion of potential recharge is rejected as surface runoff. Although the proportion of effective rainfall infiltrating to the water table is not known with certainty, it is assumed that 75% is a realistic estimate, consequently the actual annual recharge in the area is therefore approximately 390 mm.

These calculations are summarised below:

Average annual rainfall	1050 mm
Estimated P.E.	560 mm
Estimated A.E. (95% P.E.)	532 mm
Effective rainfall	518 mm
Recharge (75% E.R.)	390 mm

6.5 Hydrochemistry and water quality

Two raw water samples were taken for chemical and bacterial analysis. The hydrochemical analyses indicate a **' hard '** water (241 - 253 mg/l $CaCO_3$) with a moderate alkalinity (120 - 135 mg/l $CaCO_3$). These values are higher than normal for the Ballytrasna Formation. Conductivities were between 574 and 586 µS/cm). All the major cations, anions and trace elements are within EC limits, except for nitrate (75 mg/l) and faecal coliforms (7 per100 ml on 29/6/93). In adition chloride concentrations (44 - 47 mg/l) are higher than expected (this may be associated with pollution or due to proximity to the coast). No comprehensive well head analyses were performed, however the temperature and conductivity of the groundwater measured on 28/2/96 were 10.3°C and 503 µS/cm.

6.6 Aquifer coefficients

The pumping test analyses provided transmissivities of 10 m²/d from the 3 hour recovery test. The variable discharge during the pumping test means an accurate figure for transmissivity cannot be derived graphically. Problems also occured during the drawdown test as the pump cut in and out depending on the water level in the well. A transmissivity of 40 m²/d is suggested by an examination of the specific capacity of the supply during the drawdown test; however, a value of 10 m²/d is taken as the most reasonable figure based on numerical modelling of the source.

The specific capacity calculated from the pumping test was 33 m³/d/m after 1 hours pumping. More comprehensive pumping tests would be needed to confirm the sustainable maximum yield of the supply.

6.7 Conceptual model

The aquifer feeding the well is the Ballytrasna Formation. This is overlain by 0 to 10 metres of sandy till that is moderately permeable, therefore the aquifer can be considered to be unconfined.

Groundwater flow is influenced by topography and a groundwater mound is present to the west of the supply; groundwater therefore flows eastwards to the stream adjacent to the supply. A topographic divide is present approximately 800 m to the west of the well and is assumed to coincide with a groundwater divide (Figure 4).

The stream adjacent to the supply is perennial, therefore groundwater will flow into this steam all year round. However, the static water level in the area immediately surrounding the well is lower than the nearby stream during the summer months (2 m below the level of the nearest stream). Together with the relatively low permeability of the bedrock (0.3 m/d) and low specific yield (estimated at 0.005), this suggests that the water levels in the vicinity of the source are a reflection of the aquifer being dewatered by the public supply.

The public supply may be drawing some water from the nearby stream during the summer, however the available pumping test data and measurements of conductivity and temperature do not allow this to be verified. Controlled measurements of conductivity and temperature are needed during the summer to confirm the relationship between the public supply and the adjacent stream.

The higher than normal hardness and alkalinity values may be the result of water percolating through subsoils with a high calcium carbonate content.

6.8 Aquifer category

The Ballytrasna Formation is classed as a **locally important** aquifer which is **moderately productive only in local zones.**

7. VULNERABILITY

The source at Grange is regarded as being high to extremely vulnerable to pollution. Subsoils are moderately permeable and less than 10m thick throughout most of the area. In addition the well may be drawing water from the adjacent stream during the summer so the area immediately surrounding the stream upgradient of the well is also considered extremely vulnerable. The vulnerability is shown in Figure 3.

8. DELINEATION OF SOURCE PROTECTION AREAS

8.1 Outer protection area

The Outer Protection Area (SO) includes the complete catchment area to the source, i.e. the zone of contribution (ZOC), and it is delineated as the area required to support an abstraction from long-term recharge. The ZOC is delineated by the following methods:

i) By calculating an area required to provide the abstraction, using the average recharge and the pumping rate.

ii) Numerical modelling and hydrogeological mapping techniques.

iii) Encorporating a safety margin, if considered advisable, to allow for errors in the estimation of groundwater flow direction

Taking the average annual recharge to be 390 mm as previously indicated, the area required to supply an increased pumping rate of 175 m^3/d, is calculated to be 0.16 km^2 (the pumping rate is increased to take account of enlargement of the ZOC in dry weather and any potential increases in discharge). This is equivalent to a circular area with a radius of 230 m. In addition the area of the ZOC immediately surrounding the well has been enlarged because the aquifer is dewatered during the summer.

The most accurate ZOC at Grange is derived from numerical modelling of the groundwater system together with hydrogeological mapping techniques. The ZOC is controlled primarily by the groundwater flow direction and by the groundwater divide 800 m to the west of the source. The ZOC is extended to the divide.

The parameters used in modelling the source are listed below:

Discharge	175 m^3/d
Aquifer thickness	30 m
Hydraulic conductivity	0.3 m/d
Effective porosity	0.005
Recharge	390 mm/yr

A conservative null point (the distance down gradient after which water is not contributing to the well) is also taken to allow for dewatering of the aquifer around the public supply in dry weather. A buffer (safety margin) is included in the final zone of contribution by incorporating a ±20% error margin in the proposed groundwater flow direction. Modelling suggests that some water may be drawn from east of the stream by the public supply. The zone of contribution is shown in Figure 4.

8.2 Inner protection area

The Inner Protection Area (SI) is the area defined by a 100 day time of travel from a point below the water table to the source and it is delineated to protect against the effects of potentially contaminating activities which may have an immediate influence on water quality at the source, in particular from microbial contamination.

Numerical modelling was used to derive the 100 day time of travel zone which extends approximately 330 m upgradient of the well.

8.3 Source site

In addition to the Inner and Outer Areas there is a third protection area, the Source Site (SS), which is delineated as the area in the immediate vicinity of the source (minimum 10 m radius) in order to maintain good wellhead sanitary protection. The creamery yard immediately surrounding the source at Grange is designated the Source Site Area.

9. GROUNDWATER PROTECTION SCHEME

Combining the Source Protection Areas, as described above, with the vulnerability ratings produces four groundwater protection zones for the source at Grange. These are listed here in order of decreasing degree of protection required and are shown in Figure 5 (with the exception of the Source Site):

- Source Site / Extreme
- Inner Protection Area / Extreme
- Inner Protection Area / High
- Outer Protection Area / High

It is not within the scope of this report to delineate the protection zones in the surrounding area and this is dealt with on the regional resource protection maps.

The accompanying code of practice imposing restrictions on developments will follow when discussions as to the degree of restriction necessary in each protection zone have been carried out between the Council, the EPA and the GSI.

10. POTENTIAL POLLUTION SOURCES

The current primary threat to the public supply at Grange is the storage of large quantities of inorganic fertilizer in the creamery yard immediately surrounding the well. This is reflected in the high nitrate values in the groundwater sampled. The quality of the water in the stream adjacent to the source, if polluted, may affect the water quality in the public supply. Pollutants in the stream may account for the elevated levels of bacteria found in the supply or this may be the result of a septic tank on the creamery site. Several farms are present upgradient of the source, however most of these are more than 500 m distant.

11. CONCLUSIONS AND RECOMMENDATIONS

Overall the source at Grange is a moderate yielding well which may be drawing some water from the adjacent stream during the summer months. The area around the supply (including the nearby stream) is high to extremely vulnerable to pollution. Large quantities of inorganic fertilizer are stored next to the well and this is the most likely cause of the high nitrate values found in the groundwater. The public supply may be affected by the water quality in the stream and the presence of E.coli in one of the samples may be due to pollutants in the nearby stream and/or a septic tank on the creamery site.

It is recommended that the Council consider closing down the well at Grange creamery. Even if the creamery site was not used to store fertilizer it is likely that the groundwater and the unsaturated zone surrounding the well would be contaminated for some time.

In the meantime, if a pollution scare occurs in the stream, upstream of the well, the well should be turned off to try and prevent the drawing in of possible contaminants into the aquifer.

12. ACKNOWLEDGEMENTS

This report is a follow up to original work carried out by Sara Duffy in 1992/1993 for an M.Eng.Sc. entitled 'The Protection of Groundwater Resources in County Waterford'. The M.Eng.Sc. was supervised by Professor Con Cunnane (University College Galway) and Mr Paul Johnston (Trinity College Dublin) in conjunction with the Geological Survey and Waterford County Council.


SCALE 6 Inches = 1 Mile
Public supply well
Geological Boundary
Dip of Bedding
FIG. 1 GEOLOGY
Gyleen Formation
Ballytrasna Formation
Ballylangadon House
DRUMGULLANE WEST
DRUMGULLANE EAST
CUSHOFERANGE
BALLYBRUSA WEST
BALLYBRUSA OR BRUCETOWN
BALLYBRUSA EAST
KNOCKAUN NAGOUN
KNOCKMEELMORE
LISSANISKA
MILLAND CHURCHQUARTER
BAWNAGARRANE
TINNALYRA
ILMEEDY EAST
Grange School
St. Mary's Catholic Church
Post Office
Grave Yard


SCALE 6 Inches = 1 Mile
Subsoil boundaries
Outcrop
Depth to Bedrock Contours
3m
Alluvium
Sandstone Till
CRALLAGE LOWER
BALLYLANGADON
DRUMGULLANE WEST
DRUMGULLANE EAST
CUSHOFERANCE
ILMEEDY EAST
TINNALYRA
BALLYBRUSA WEST
BALLYBRUSA OR BRUCETOWN
BALLYBRUSA EAST
KNOCKAUN NAGOUN
MOANBALLY-SHIVANE
LISSANISKA
KNOCKMEELMORE
MILL AND CHURCHQUARTER
BAWNACARRANE
RODEEN
ERRILL
Ballylangadon House
Grange St. Mary's Catholic Church
Grange School
Kilknockan Ho.
Post Office
Grave Yard
Stepping Stones
Ford
Rivers
FIG. 2 SUBSOILS AND DEPTH TO BEDROCK

FIG. 3 VULNERABILITY

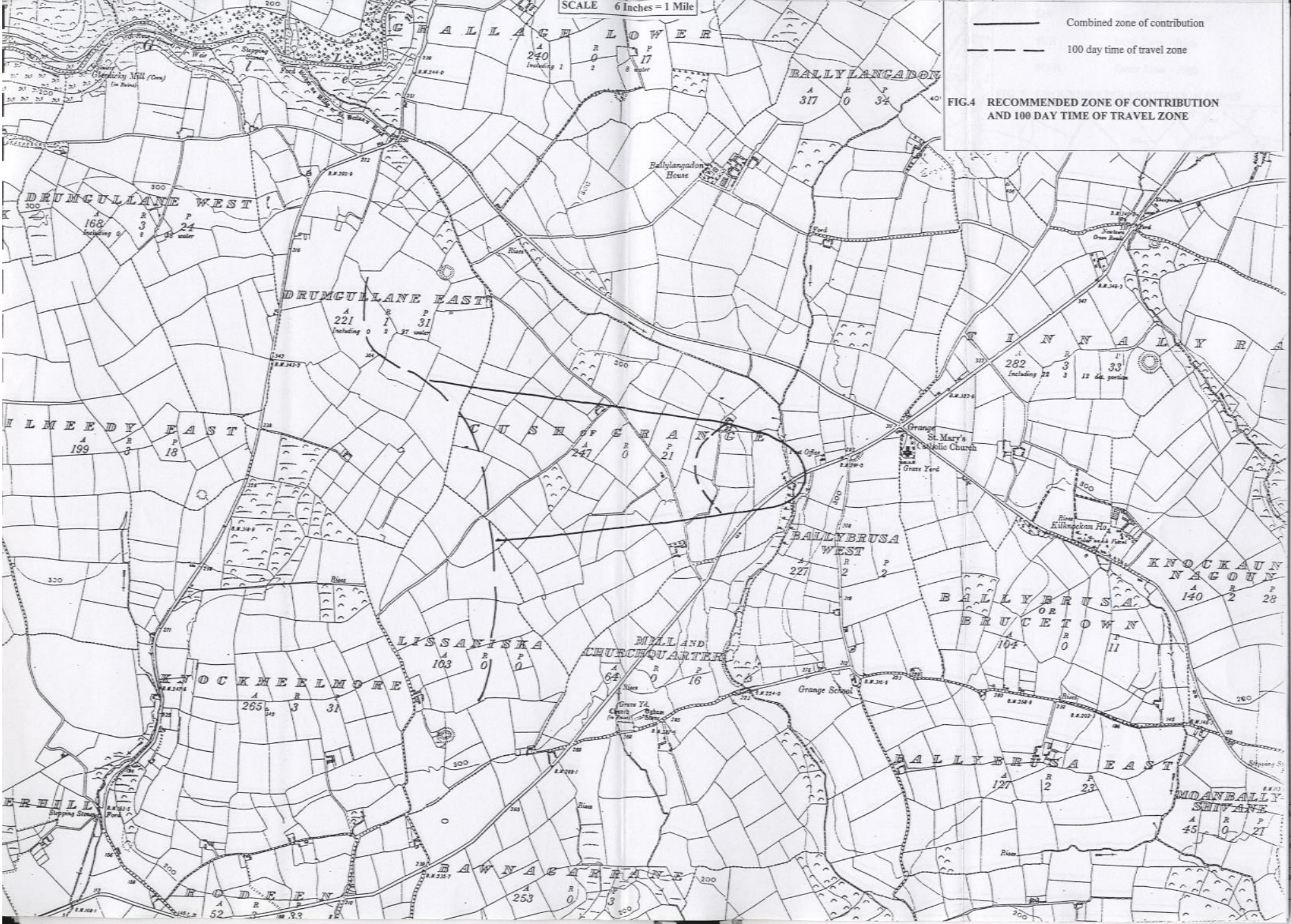
SCALE 6 Inches = 1 Mile
Combined zone of contribution
100 day time of travel zone
FIG.4 RECOMMENDED ZONE OF CONTRIBUTION AND 100 DAY TIME OF TRAVEL ZONE
DRUMGULLANE WEST
DRUMGULLANE EAST
CUSHOFGRANGE
BALLYLANGADON
TINNALYRA
KILMEEDY EAST
LISSANISKA
KNOCKEELMORE
MILL AND CHURCHQUARTER
BALLYBRUSA WEST
BALLYBRUSA OR BRUCETOWN
BALLYBRUSA EAST
KNOCKAUN NAGOUN
MOANBALLY SHIVANE
BAWNACARRANE
Ballylangadon House
Grange St. Mary's Catholic Church
Grave Yard
Grange School
Kilknockan Ho.
Glenbrickey Mill (Corn) (in Ruins)

FIG. 5 GROUNDWATER PROTECTION ZONES